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In re Patent Application of

Group Art Unit: 1763

Examiner: LUZ L ALEJANDRO
MULERO

Appeal No.: Unassigned

[illegible]

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

This appeal is from the decision of the Primary Examiner dated July 26, 2005, finally rejecting claims 1, 3-10, 21, 25, 27, 30, 31 and 33-41, which are reproduced as the Claims Appendix of this brief.

Government fee is filed herewith.

The Commissioner is hereby authorized to charge any appropriate fees under 37 C.F.R. §§1.16, 1.17, and 1.21 that may be required by this paper, and to credit any overpayment, to Deposit Account No. 02-4800.

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I. REAL PARTY IN INTEREST

The present application is assigned to Lam Research Corporation. The Appellants' legal representative, or assignee, does not know of any other appeal or interferences, which will affect or be directly affected by or have bearing on the Board's decision in the pending appeal.

II. STATUS OF CLAIMS

Claims 1, 3-10, 21, 25, 27, 30, 31 and 33-41 are pending in the application. These claims are being appealed.

III. STATUS OF AMENDMENTS

No Amendments were filed subsequent to the final Official Action dated October 26, 2005.

IV. SUMMARY OF CLAIMED SUBJECT MATTER

Claims 1, 3-7, 21, 25, 27, 30, 31 and 33-38 are directed to a low resistivity silicon electrode adapted to be mounted in a plasma reaction chamber including a confinement ring which is used in semiconductor substrate processing. Claims 8-10 are directed to a plasma etch reactor including a low resistivity silicon electrode. Claims 39-41 are directed to a plasma etch reactor including a low resistivity silicon electrode and a confinement ring.

Independent Claim 1 recites a low resistivity silicon electrode adapted to be mounted in a plasma reaction chamber including a confinement ring, which is used

in semiconductor substrate processing. The low resistivity silicon electrode comprises a silicon electrode comprising a showerhead electrode having a plurality of gas outlets arranged to distribute process gas in the plasma reaction chamber during use of the showerhead electrode. The electrode has a thickness of about 0.25 inch to 0.5 inch and an electrical resistivity of about 0.005 to 0.1 ohm-cm. The electrode has an RF driven or electrically grounded surface on one side thereof, and the surface is exposed to plasma in the plasma reaction chamber during use of the electrode.

Figure 2 depicts an exemplary embodiment of an electrode assembly 10 including an electrode plate 12 having a plurality of gas outlets 16 arranged to distribute process gas in a plasma reaction chamber, such as the parallel plate reaction chamber 52 depicted in Figure 1. The electrode plate 12 is a showerhead electrode. See page 7, lines 3-12, and the paragraph bridging pages 7-8 of the specification. The recited low resistivity of the electrode is described at, for example, page 3, lines 13-14, and page 11, lines 3-4, of the specification. The recited thickness of the low resistivity silicon electrode is described at page 13, lines 15-21, of the specification. The low resistivity electrode can have a thickness of 0.25 inch (page 14, lines 7-9, of the specification) or a greater thickness (page 13, lines 19-21, of the specification).

Figure 5 illustrates a reaction chamber 224 containing an electrode 210 having gas distribution holes (outlets) to disperse process gas into the reaction chamber. A confinement ring 217 surrounds the electrode 210. The confinement ring 217 causes a pressure differential in the reactor chamber and increases the electrical resistance between the chamber walls and the plasma to thereby confine

plasma between the upper electrode 210 and a lower electrode of the reaction chamber. See the description at page 9, lines 7-19, of the specification.

Independent Claim 21 recites a low resistivity silicon electrode adapted to be mounted in a plasma reaction chamber including a confinement ring, which is used in semiconductor substrate processing. The low resistivity silicon electrode comprises a silicon electrode comprising a showerhead electrode having a plurality of gas outlets arranged to distribute process gas in the plasma reaction chamber during use of the showerhead electrode. The gas outlets have a diameter of about 0.025 inch to 0.030 inch, and the electrode has a thickness of about 0.25 inch to 0.5 inch and an electrical resistivity of less than about 0.1 ohm-cm. The electrode has an RF driven or electrically grounded surface on one side thereof, where the surface is exposed to plasma in the plasma reaction chamber during use of the electrode. The low resistivity silicon electrode also comprises a backing ring elastomer bonded to the electrode.

Figure 6 depicts an exemplary embodiment of the low resistivity silicon electrode comprising a support ring 212 (backing ring). Figure 7 shows an exemplary embodiment of an elastomeric joint 246 bonding the support ring 212 to the low resistivity silicon electrode 210. See page 10, lines 10-12, of the specification.

Independent Claim 30 recites a low resistivity silicon electrode adapted to be mounted in a plasma reaction chamber including a confinement ring, which is used in semiconductor substrate processing. The low resistivity silicon electrode comprises a silicon electrode comprising a showerhead electrode having a plurality of gas outlets arranged to distribute process gas in the plasma reaction chamber

during use of the showerhead electrode. The electrode has a thickness of about 0.375 inch to 0.5 inch and an electrical resistivity of less than about 0.1 ohm-cm. The electrode has an RF driven or electrically grounded surface on one side thereof, where the surface is exposed to plasma in the plasma reaction chamber during use of the electrode. The low resistivity silicon electrode also comprises a graphite backing ring elastomer bonded to the electrode.

As described at, for example, page 9, lines 19-21, of the specification, the support ring 212 can be of graphite.

V. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

- 1) The rejection of Claims 1, 3-10, 21, 25, 27, 31, 34, 35, 37, 39 and 40 under 35 U.S.C. § 112, first paragraph.
- 2) The rejection of Claims 1, 4-10, 30, 38, 39 and 41 under 35 U.S.C. § 103(a) over U.S. Patent No. 5,074,456 to Degner et al. ("Degner") in view of JP 2-20018 ("Murai").
- 3) The rejection of Claims 3, 21, 25, 27, 31, 33-37 and 40 under 35 U.S.C. § 103(a) over Degner in view of Murai and U.S. Patent No. 5,993,597 to Saito et al. ("Saito").
- 4) The rejection of Claims 1, 4-10, 30, 38, 39 and 41 under 35 U.S.C. § 103(a) over Murai in view of Degner.
- 5) The rejection of Claims 3, 21, 25, 27, 33-37 and 40 under 35 U.S.C. § 103(a) over Murai in view of Degner and Saito.
- 6) The rejection of Claims 1, 3-10, 21, 25, 27, 30, 31 and 33-41 under 35 U.S.C. § 103(a) over Saito in view of Degner.

7) The rejection of Claims 1, 3-10, 21, 25, 27, 30, 31 and 33-41 under 35 U.S.C. § 103(a) over Degner in view of Saito.

VI. ARGUMENT

A. Rejection of Claims 1, 3-10, 21, 25, 27, 31, 34, 35, 37, 39 and 40 Under 35 U.S.C. § 112, First Paragraph

The Examiner contends in the final Official Action that the rejected claims contain subject matter that was not sufficiently described in the specification to satisfy the “written description” requirement of 35 U.S.C. § 112, first paragraph. More particularly, the Examiner contends that the originally-filed specification does not provide support for the recitation of “the electrode having a thickness of about 0.25 inch to 0.5 inch” in independent Claims 1 and 21. Appellants submit that this rejection should be reversed for the following reasons.

The original disclosure provides explicit support for the recitation of “the electrode having a thickness of about 0.25 inch to 0.5 inch.” Support for an electrode having a thickness of 0.25 inch is provided at page 14, lines 7-9, of the specification. Support for an electrode thickness of 0.375 inch and 0.5 inch is provided at page 13, lines 15-21, of the specification, which describes an approach for enhancing reduction of the center-to-edge temperature variation across the electrode “by making the electrode thicker than conventional electrodes”. A “conventional 0.25 inch thick electrode” is described at page 13, line 21 of the specification. The specification describes at page 13, lines 19-20, “for example, the electrode can have an increased thickness of 0.375 or even 0.50 inch compared to a conventional 0.25 inch thick electrode.” Accordingly, the specification provides an

example of an electrode having a thickness of 0.25 inch, a description of an electrode having a thickness of greater than 0.25 inch, and examples of electrodes having a thickness of 0.375 inch and 0.5 inch. As such, the specification provides a written description of the claimed electrode thickness of about 0.25 inch to 0.5 inch. See Ex parte Jackson, 110 USPQ 561, 562 (Bd. App. 1956).

Therefore, the rejection under 35 U.S.C. § 112, first paragraph, should be reversed.

B. Legal Standards for Obviousness

In order to establish *prima facie* obviousness of claimed subject matter, the U.S. Patent and Trademark Office ("PTO") has the burden to show (1) "some suggestion or motivation in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to ... combine the reference teachings"; (2) "a reasonable expectation of success"; and that (3) "the prior art ... references when combined ... must teach or suggest all the claim limitations." See M.P.E.P. § 2143 at page 2100-135.

"The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art, not in applicant's disclosure" (citation omitted). Id. As stated in In re Lee, 61 USPQ2d, 1430, 1434 (Fed. Cir. 2002):

It is improper, in determining whether a person of ordinary skill would have been led to use this combination of references, simply to [use] that which the inventor taught against its teacher. (Citation omitted).

Finding individual features of a claim in different selected prior art references is not a sufficient basis to establish *prima facie* obviousness; rather, the art must also suggest the desirability of the proposed combination. Merely because art may be modified to result in claimed subject matter does not render the claimed subject matter obvious. In re Fritch, 23 USPQ2d 1780, 1783-84, n. 14 (Fed. Cir. 1992).

The Court of Appeals for the Federal Circuit addressed the issue of combined-reference obviousness under 35 U.S.C. § 103 in In re Kotzab, 55 USPQ2d 1313, 1316-17 (Fed. Cir. 2000). The court stated that:

[m]ost if not all inventions arise from a combination of old elements. Thus, every element of a claimed invention may often be found in the prior art. However, identification in the prior art of each individual part claimed is insufficient to defeat patentability of the whole claimed invention. Rather, to establish obviousness based on a combination of the elements disclosed in the prior art, there must be some motivation, suggestion or teaching of the desirability of making the specific combination that was made by applicant. (Citations omitted).

The proposed modification's effects on the ability of the base reference to achieve its intended purpose and on the base reference's principle of operation are factors of an obviousness determination. Where a proposed modification of a base reference would render that reference unable to achieve its intended purpose, the applied references provide no suggestion or motivation to modify the base reference. In re Gordon, 221 USPQ 1125, 1127 (Fed. Cir. 1984). See also, In re Spinnoble, 160 USPQ 237, 244 (CCPA 1969) (a combination of references that would produce a seemingly inoperative device teaches away from the proposed combination); Ex

Parte Westphalen, 159 USPQ 507, 508 (Bd. App. 1967); Ex Parte Hartmann, 186 USPQ 366, 367 (Bd. App. 1974) (a combination of references that would destroy the device of the base reference for its intended purpose would not have rendered obvious the claimed subject matter); and In re Ratti, 123 USPQ 349, 352 (CCPA 1959) (a proposed combination of references that changes the basic principles under which the base reference construction was designed to operate is improper).

C. Rejection of Claims 1, 4-10, 30, 38, 39 and 41 Under 35 U.S.C. § 103(a) Over Degner in View of Murai

1. Claims 1, 4, 5 and 8-10

Claim 1 recites “a low resistivity silicon electrode adapted to be mounted in a plasma reaction chamber including a confinement ring which is used in semiconductor substrate processing, comprising: a silicon electrode comprising a showerhead electrode having a plurality of gas outlets arranged to distribute process gas in the plasma reaction chamber during use of the showerhead electrode, the electrode having a thickness of about 0.25 inch to 0.5 inch and an electrical resistivity of about 0.005 to 0.1 ohm-cm” (emphasis added).

The claimed low resistivity silicon electrode provides unexpected advantages as compared to other electrodes that do not have the claimed combination of thickness and low resistivity. Particularly, Appellants determined that making the electrode 0.25 inch and thicker unexpectedly allows the electrode to be used longer for plasma processing (i.e., increases the electrode lifetime) and allows the electrode to be used at higher power levels without cracking failure. Increasing the electrode thickness also decreases the electrical resistance of the electrode from the center to

the edge, but increases its resistance in the thickness direction. Appellants further determined that by decreasing the electrical resistivity of the electrode, the electrode's resistance is decreased, which increases the confinement window and the corresponding process window. These unexpected advantages are discussed in greater detail below.

The combination of Degner and Murai fails to suggest the low resistivity silicon electrode recited in Claim 1. The Examiner states that Degner discloses a single crystal silicon electrode 12 adapted to be mounted in a parallel plate plasma reaction chamber, and having a thickness in the range of from about 0.1 cm to 2 cm. The Examiner acknowledges that Degner does not disclose that the electrode is a single crystal silicon electrode having an electrical resistivity of less than 0.05 ohm-cm.

The Examiner states that Murai discloses a single crystal silicon electrode having an electrical resistivity of less than 0.05 ohm-cm, and contends that it would have been obvious to modify Degner's apparatus to include an electrode having such electrical resistivity. Appellants disagree.

As discussed above, Degner discloses an electrode 12 having a thickness from 0.1 cm to 2 cm (0.04 inch to 0.79 inch). Degner does not disclose any specific thickness of any of the respective electrode materials listed at column 4, lines 10-20. However, Degner discloses at column 4, lines 25-29, that it is desirable to minimize the thickness of the electrode for expensive materials. Single crystal silicon is an expensive material. Degner discloses that electrodes as thin as 0.1 cm (0.12 inch) can be used. Appellants submit that Degner does not suggest the claimed silicon

electrode thickness. Degner also does not suggest that increasing the electrode thickness reduces cracking failure even at high applied power levels.

Murai discloses an upper electrode 2a composed of doped silicon. See the Abstract. The electrode is doped with the same element (e.g., phosphorus) that is doped in the wafer 1 being processed in the chamber 5. Murai is silent regarding the thickness of the upper electrode 2a.

Accordingly, neither Degner nor Murai suggests a low resistivity silicon electrode having the thickness range of about 0.25 inch to 0.5 inch recited in Claim 1. Neither Degner nor Murai recognizes the cracking problem that was solved by the claimed 0.25 inch and thicker electrode. As such, the applied references could not have suggested a solution to the electrode cracking problem. See In re Shaffer, 108 USPQ 326, 329 (CCPA 1956).

Also, the Examiner has established no motivation for making Degner's electrode from the doped material disclosed by Murai. Murai discloses that the electrode is highly doped for the specific purpose of avoiding contamination of the wafer 1, which is doped in the chamber 5 with the same dopant. Degner does not suggest doping a wafer in a plasma processing chamber. As such, the combination of Degner and Murai would not have suggested modifying Degner's electrode to result in the low resistivity silicon electrode recited in Claim 1 having a thickness of about 0.25 inch to 0.5 inch and an electrical resistivity of about 0.005 to 0.1 ohm-cm. Thus, the Examiner has not established *prima facie* obviousness with respect to the claimed electrode.

Furthermore, the claimed low resistivity silicon electrode provides unexpected superiority over electrodes that do not have the claimed combination of thickness

and low resistivity. To demonstrate this unexpected superiority, Appellants submitted a Second Declaration By Jerome S. Hubacek Under 37 C.F.R. § 1.132 ("the second Hubacek Declaration") with the Amendment filed on March 29, 2005 (copy attached). The second Hubacek Declaration provided evidence of the unexpected superiority of the claimed subject matter as compared to the prior art; namely, the claimed low resistivity, silicon electrode provides (a) a reduced center-to-edge temperature gradient; (b) an increased lifetime; (c) reduced byproduct deposition behind the electrode; (d) reduced electrical resistance; **and** (e) increased plasma confinement.

As explained at M.P.E.P. § 716.02(e), page 700-272, "an affidavit or declaration under 37 C.F.R. 1.132 must compare the claimed subject matter with the **closest prior art** to be effective to rebut a *prima facie* case of obviousness" (emphasis added, citation omitted). There is no requirement to compare the claimed subject matter with subject matter suggested by a **combination of references** relied upon in a rejection under 35 U.S.C. § 103, as this "would be requiring comparison of the results of the invention and the results of the invention." See In re Chapman, 148 USPQ 711, 714 (CCPA 1966) and MPEP § 716.02(e)(III), page 700-273. Thus, it is improper for the PTO to compare the results of the claimed subject matter to subject matter that is allegedly disclosed in **the combination of Degner and Murai**,

or *vice versa*. With respect to this ground of rejection, the claimed subject matter should be properly compared to Degner.¹

As discussed above, the claimed low resistivity silicon electrode provides a reduced electrode center-to-edge temperature gradient and an associated longer electrode lifetime. At paragraphs (2) and (3) of the second Hubacek Declaration, testing procedures and results for low resistivity, single crystal silicon showerhead electrodes having respective thicknesses of 0.15 inch, 0.18 inch, 0.25 inch, and 0.35 inch are explained. The comparative results plotted in the graph in Appendix A attached to the second Hubacek Declaration show that for each applied power level, the center-to-edge temperature gradient decreases as the showerhead electrode thickness increases. Accordingly, the electrodes having a thickness of 0.25 inch and 0.35 inch have a reduced center-to-edge temperature gradient as compared to the electrodes having a thickness of 0.15 inch and 0.18 inch, which fall outside of the claimed thickness range. In addition, the electrode having a thickness of 0.35 inch has a reduced center-to-edge temperature gradient as compared to the electrode having a thickness of 0.25 inch at each applied power level. As also shown in the graph, as the applied power level is increased, the difference between the center-to-edge temperature gradient for an electrode thickness of 0.15 inch and for an electrode thickness of 0.35 inch increases.

Reducing the center-to-edge temperature of the electrode surprisingly reduces the probability of cracking of the electrode, especially at higher power levels.

¹ In each of the other art rejections discussed below, the claimed subject matter and its corresponding unexpected results should be properly compared to the closest single prior art reference, not to the different applied combinations of references.

Increasing the showerhead electrode thickness increases the lifetime of the electrode, i.e., the number of RF hours that the electrode can be operated for without failing by cracking. The relationship between showerhead electrode thickness and the power level applied to the electrode is plotted in the graph in Appendix B attached to the second Hubacek Declaration. In this graph, Line A can be extrapolated to higher electrode thickness values (e.g., up to 0.5 inch) to show that by increasing the showerhead electrode thickness from 0.25 inch to 0.5 inch, the electrode can be operated at increasingly higher power levels. Degner and Murai both fail to recognize the unexpected advantage that 0.25 inch and thicker low resistivity silicon electrodes can be operated at higher power levels without cracking than can thinner electrodes.

Despite this showing of unexpected results associated with the claimed low resistivity silicon electrode, in the paragraph bridging pages 20-21 of the final Official Action, the Examiner states that these results are "expected," but fails to provide any evidence suggesting that the probability of cracking of an electrode is reduced by making it 0.25 inch and thicker.

The Examiner contends that U.S. Patent No. 5,993,596 to Uwai et al. ("Uwai") supports the position that the test results in the second Hubacek Declaration are "expected." Appellants disagree. Uwai discloses glassy carbon electrodes attached to a metal cooling plate in a plasma reactor. Uwai does not suggest that the glassy carbon electrodes can provide improved resistance to cracking, as is unexpectedly provided by the low resistivity electrode having the combination of features recited in Claim 1.

The Examiner contends that Appendix B provides “an extremely small sample from which to draw any conclusions” (final Official Action at page 20, last line to page 21, line 1). Appellants disagree. The data points in the graph in Appendix B show the clear trend that by increasing the electrode thickness, the power level that can be applied to the electrode without cracking failure increases. The probative value of the range of data shown in this graph can be extended to higher values of the claimed electrode thickness range because one skilled in the art could readily ascertain this trend in the exemplified data that would reasonably allow him to extend its probative value. See In re Kollman, 201 USPQ 193, 199 (CCPA 1979).

As discussed at paragraph (5) of the second Hubacek Declaration, the claimed low resistivity silicon electrode also reduces byproduct deposition behind the electrode. Particularly, increasing the showerhead electrode thickness increases the length of the gas passages and the pressure behind the electrode. As an example, a showerhead electrode thickness of 0.35 inch reduces backstreaming, i.e., the deposition of particle defects behind the electrode, as compared to electrodes having a thickness of only 0.15 inch and 0.18 inch, which fall outside of the scope of Claim 1. The applied prior art clearly fails to recognize the advantage of reducing by-product deposition by increasing the electrode thickness.

The second Hubacek Declaration further explains at paragraph (6) that increasing the thickness of the showerhead electrode decreases its (center-to-edge) electrical resistance. The second Hubacek Declaration explains that reducing the impedance path of the RF provides for a higher etch rate of substrates in the plasma reactor at a set power level applied to the electrode and, surprisingly, an etch uniformity as good as, or better than, that of a lower resistance electrode, e.g., an

electrode that is not as thick as the claimed electrode. Particularly, as shown in the Table at page 14 of the present specification, reducing the impedance path of the RF results in a higher etch rate of substrates in the plasma reactor using the same gas chemistry and reactor conditions, including the same set power level applied to the electrode. As described in the paragraph bridging pages 11 to 12 of the specification, it is contemplated that additional power can be delivered to the plasma for a given applied power level. These additional advantages provided by the claimed combination of electrode thickness and electrical resistivity are not recognized in the applied references.

As discussed at paragraph (7) of the second Hubacek Declaration, the claimed low resistivity silicon electrode enhances plasma confinement. Advantageous effects are achieved by the claimed combination of electrode thickness and low resistivity. Tests were performed using low resistivity, single crystal silicon showerhead electrodes A-D, and a standard higher resistivity single crystal silicon showerhead electrode, in a plasma reaction chamber. The low resistivity showerhead electrodes had a thickness of 0.25 inch and an electrical resistivity of from about 0.005-0.02 ohm-cm. The standard resistivity showerhead electrode had a thickness of 0.25 inch and an electrical resistivity of 10 ohm-cm.

The standard resistivity and low resistivity showerhead electrodes were installed in a plasma reactor including a plasma confinement ring assembly for confining the plasma in a confinement region between the showerhead electrode and the lower electrode. Each of the electrodes was tested to determine the maximum flow rate of a constituent of the gas mixture (argon) that could be used without plasma unconfinement in the plasma reactor. The flow rate of argon was

increased while maintaining the same flow rates of the other gases of the gas mixture.

The test results are shown in Appendix C attached to the second Hubacek Declaration. For the standard resistivity showerhead electrode, there was plasma unconfinement at an argon flow rate of less than 200 sccm. In contrast, for the low resistivity showerhead electrodes, higher argon flow rates ranging from 200 sccm (showerhead electrode D) up to 1000 sccm (showerhead electrode A) were used with stable plasma operation. The higher argon flow rates provide a desirable larger confinement window for plasma processing operations using the low resistivity showerhead electrodes.

Appendix D attached to the second Hubacek Declaration shows the measured impedance values for the low resistivity showerhead electrodes A, B and D. As shown in Appendix D, for both operating frequencies, showerhead electrode A had the lowest impedance value, showerhead electrode D had the highest impedance value and showerhead electrode B had an intermediate impedance value. The impedance values shown in Appendix D correlate to the plasma confinement results shown in Appendix C for the low resistivity showerhead electrodes, thereby demonstrating that decreasing the impedance of the electrode improves confinement. These unexpected results are highly desirable in semiconductor processing because by improving confinement, the confinement window and the corresponding process window are increased. See also the description at page 11, line 17, to page 12, line 6, of the specification.

Despite this additional showing of unexpected results, the Examiner contends at page 21, lines 12-14, that "the data shown in appendix C and D are insufficient to

show unexpected results with respect to the claimed resistivity range.” Appellants disagree. First, the Examiner gives no specific reasons to support this statement. Second, the PTO should properly weigh these test results as part of the evidence as a whole, especially in light of the fact that Degner discloses no numerical electrical resistivity value for the electrode. See M.P.E.P. § 716.01(d).

Appellants submit that the unexpected results set forth in the second Hubacek Declaration that are associated with the claimed low resistivity silicon electrode having the recited thickness and resistivity values are sufficient to rebut the alleged *prima facie* obviousness. Accordingly, the low resistivity silicon electrode recited in Claim 1 is patentable. Therefore, the rejection of Claims 1, 4, 5 and 8-10 should be reversed.

2. Claims 6 and 7

Claim 6 depends from Claim 1 and recites that “the electrical resistivity of the electrode is less than 0.025 ohm-cm.” Claim 7 depends from Claim 1 and recites that “the electrical resistivity of the electrode is less than 0.05 ohm-cm.” The combination of Degner and Murai does not recognize the unexpected advantages that are provided by the claimed low resistivity silicon electrode having the recited thickness and low resistivity of Claims 6 and 7. For example, the test results discussed in the second Hubacek Declaration regarding Appendices C and D demonstrate that the claimed combination of electrode thickness and low resistivity of the silicon electrode decreases impedance, thereby improving plasma confinement and enhancing the process window. Appellants submit that the subject matter recited in Claims 6 and 7 is also patentable over the applied combination of references. Therefore, the rejection of Claims 6 and 7 should be reversed.

3. Claims 30 and 38

Independent Claim 30 recites “a low resistivity silicon electrode adapted to be mounted in a plasma reaction chamber including a confinement ring which is used in semiconductor substrate processing, comprising: a silicon electrode comprising a showerhead electrode having a plurality of gas outlets arranged to distribute process gas in the plasma reaction chamber during use of the showerhead electrode, the electrode having a thickness of about 0.375 inch to 0.5 inch and an electrical resistivity of less than about 0.1 ohm-cm ... and a graphite backing ring elastomer bonded to the electrode” (emphasis added).

The combination of Degner and Murai does not suggest replacing Degner's electrode with Murai's doped electrode, much less to result in the low resistivity silicon electrode recited in Claim 30 having a thickness of about 0.375 inch to 0.5 inch and an electrical resistivity of less than about 0.1 ohm-cm. As discussed above with reference to the second Hubacek Declaration, the claimed electrode having a thickness of from about 0.375 inch to 0.5 inch provides enhanced resistance to cracking at high power levels, thereby allowing the electrode to be used for plasma processes that utilize high power levels for an extended lifetime. The claimed low resistivity reduces the electrode resistance in the thickness direction of the electrode, which provides unexpected results when the electrode is used for plasma processing of wafers, as described in the second Hubacek Declaration.

Thus, the subject matter recited in Claims 30 and 38 is patentable. Therefore, the rejection of these claims should be reversed.

4. Claim 39

Claim 39 depends from Claim 1 and is directed to a plasma etch reactor comprising an electrode assembly including the electrode of Claim 1 and a confinement ring. As discussed above, the recited confinement ring causes a pressure differential in the reactor and increases the electrical resistance between the chamber walls and the plasma to thereby confine plasma between the upper electrode and a lower electrode of the reaction chamber. The claimed low resistivity silicon electrode also unexpectedly enhances plasma confinement. As such, the combination of the claimed low resistivity silicon electrode and the confinement ring provides enhanced plasma confinement effects during plasma processing of substrates in a plasma processing chamber.

However, the Examiner fails to comment on the claimed confinement ring. As stated at M.P.E.P. § 2143.03, “all words in a claim must be considered in judging the patentability of that claim against the prior art” (citation omitted). Moreover, the Examiner has failed to identify any disclosure in Degner or Murai of a plasma etch reactor comprising an electrode assembly that also includes a confinement ring. However, as further stated at M.P.E.P. § 2143.03, “to establish *prima facie* obviousness of a claimed invention, all the claim limitations must be taught or suggested by the prior art” (emphasis added; citation omitted). Accordingly, because the combination of Degner and Murai does not disclose or suggest every feature recited in Claim 39, the applied references do not support the alleged *prima facie* obviousness. Therefore, the rejection of Claim 39 should be reversed.

5. Claim 41

Claim 41 depends from Claim 30. Claim 41 is directed to a plasma etch reactor comprising an electrode assembly including the electrode of Claim 30 and a confinement ring.

For reasons discussed above, the combination of Degner and Murai does not disclose or suggest every feature recited in Claim 41, including a confinement ring, and thus does not support the alleged *prima facie* obviousness. Therefore, the rejection of Claim 41 should be reversed.

D. Rejection of Claims 3, 21, 25, 27, 31, 33-37 and 40 Under 35 U.S.C. § 103(a) over Degner in View of Murai and Saito

1. Claims 3 and 27

Claim 3 depends from Claim 1 and recites that "the gas outlets have diameters of 0.020 to 0.030 inch and the gas outlets are distributed across the exposed surface." Degner and Murai fail to disclose the gas outlet diameter recited in Claim 3. However, the Examiner states that Saito teaches this omission and contends that it would have been obvious to modify Degner's electrode to achieve the claimed electrode. Appellants disagree.

The applied combination of references would have led away from the claimed subject matter. Saito fails to suggest an electrode thickness of about 0.25 inch to 0.5 inch. In stark contrast, Saito discloses a silicon sheet having a thickness of only 5 mm, i.e., less than 0.2 inch (column 3, lines 13-20), which is significantly thinner than the electrode thickness of about 0.25 inch to 0.5 inch recited in Claim 1. As such, Saito fails to suggest any gas outlet diameter for electrodes having the claimed thickness. Thus, the electrode recited in Claim 3 is patentable over the applied

combination of Degner, Murai and Saito. Therefore, the rejection of Claims 3 and 27 should be reversed.

2. Claims 21, 25, 31 and 37

Independent Claim 21 recites a low resistivity silicon electrode adapted to be mounted in a plasma reaction chamber including a confinement ring, which is used in semiconductor substrate processing. The electrode comprises “a silicon electrode comprising a showerhead electrode having a plurality of gas outlets arranged to distribute process gas in the plasma reaction chamber during use of the showerhead electrode, the gas outlets having a diameter of about 0.025 inch to 0.030 inch, the electrode having a thickness of about 0.25 inch to 0.5 inch and an electrical resistivity of less than about 0.1 ohm-cm ...; and a backing ring elastomer bonded to the electrode” (emphasis added).

For reasons discussed above, the combination of Degner, Murai and Saito fails to suggest a low resistivity silicon electrode “having a thickness of about 0.25 inch to 0.5 inch and an electrical resistivity of less than about 0.1 ohm-cm,” as recited in Claim 21. The claimed electrode can provide advantageous plasma confinement effects that are desirable when the electrode is mounted in a plasma reaction chamber including a confinement ring, as claimed.

Moreover, Saito fails to provide any motivation to modify Degner's electrode to include gas outlets having a diameter of about 0.025 inch to 0.030 inch, as recited in Claim 21. Saito discloses a silicon sheet that includes holes having a diameter of only 0.5 mm, i.e., less than 0.02 inch (column 3, lines 13-20). Saito provides no suggestion of modifying Degner's electrode to include gas outlets having the claimed diameter. As such, the only disclosure of the claimed outlet diameter is provided in

the present application. However, it is improper to simply use that which the inventors have taught against them. See In re Lee, 61 USPQ2d at 1434.

Accordingly, because the combination of Degner, Murai and Saito does not disclose or suggest every feature recited in Claim 21, the references do not support the alleged *prima facie* obviousness. Moreover, the above-discussed unexpected results associated with the claimed low resistivity silicon electrode are sufficient to rebut the alleged *prima facie* obviousness. Therefore, the rejection of Claims 21, 25, 31 and 37 should be reversed.

3. Claim 33

Claim 33 depends from Claim 30 and recites the features of “the gas outlets have diameters of 0.020 to 0.030 inch and the gas outlets are distributed across the exposed surface.” Appellants submit that the applied combination of references would have led away from the claimed subject matter. Saito fails to suggest modifying Degner's electrode to have a thickness of about 0.375 inch to 0.5 inch and an electrical resistivity of less than about 0.1 ohm-cm, as recited in Claim 30. In contrast, Saito discloses a silicon sheet having a thickness of less than 0.2 inch, which is significantly thinner than the electrode thickness of about 0.375 inch to 0.5 inch recited in Claim 30. Accordingly, the electrode recited in Claim 33 is also patentable over the applied combination of Degner, Murai and Saito. Therefore, the rejection of Claim 33 should be reversed.

4. Claim 34

Claim 34 depends from 3, which in turn depends from Claim 1. Claim 34 recites that “the gas outlets have a diameter of about 0.025 inch to about 0.028 inch.” Saito's silicon sheet includes holes having a diameter of less than 0.2 inch.

Accordingly, because the combination of Degner, Murai and Saito does not disclose or suggest every feature recited in Claim 34, the references do not support the alleged *prima facie* obviousness. Therefore, the rejection of Claim 34 should be reversed.

5. Claim 35

Claim 35 depends from 21 and recites that “the gas outlets have a diameter of about 0.025 inch to about 0.028 inch.” For reasons discussed above, the combination of Degner, Murai and Saito does not disclose or suggest every feature recited in Claim 35. Thus, the references do not support the alleged *prima facie* obviousness. Therefore, the rejection of Claim 35 should be reversed.

6. Claim 36

Claim 36 depends from Claim 33, which depends from Claim 30, and recites that “the gas outlets have a diameter of about 0.025 inch to about 0.028 inch.” For reasons discussed above, the combination of Degner, Murai and Saito does not disclose or suggest every feature recited in Claim 36. Thus, the references do not support the alleged *prima facie* obviousness. Therefore, the rejection of Claim 36 should be reversed.

7. Claim 40

Claim 40 depend from Claim 21. Claim 40 is directed to a plasma etch reactor comprising an electrode assembly including the electrode of Claim 21 and a confinement ring. The Examiner fails to identify any disclosure in Degner, Murai or Saito regarding a plasma etch reactor comprising an electrode assembly that includes a confinement ring, as claimed. Accordingly, because the applied combination of references does not disclose or suggest every feature recited in

Claim 40, the combination does not support the alleged *prima facie* obviousness.

Therefore, the rejection of Claim 40 should be reversed.

E. Rejection of Claims 1, 4-10, 30, 38, 39 and 41 Under 35 U.S.C. § 103(a) over Murai in View of Degner

1. Claims 1, 4 and 5

As discussed above, Murai discloses a plasma chamber including an upper electrode 2a having a specific composition for use in a process for doping a wafer 1 positioned in the chamber 5. Murai's chamber includes a gas supply tube 4 located at the sidewall of the chamber 5 to introduce the doping gas. The electrode 2a is not a showerhead electrode having a plurality of gas outlets arranged to distribute process gas in a plasma processing chamber, as recited in Claim 1.

Murai does not disclose the thickness of the upper electrode 2a. Degner does not suggest modifying Murai's electrode to produce a showerhead electrode having a thickness of about 0.25 inch to 0.5 inch, an electrical resistivity of 0.005 to 0.1 ohm-cm, and a plurality of gas outlets, as recited in Claim 1.

Degner discloses a showerhead electrode assembly 10 that has a substantially different construction than Murai's apparatus, which does not include a showerhead electrode, but which introduces gas into the chamber via the gas supply tube 4 in the sidewall of the chamber 5. In light of these substantial structural and functional differences, the asserted modification of Murai's apparatus would require it to be substantially reconstructed and redesigned and would substantially change its principle of operation. Furthermore, modifying Murai's silicon electrode by increasing its thickness would only produce a different, non-showerhead electrode, but not the claimed showerhead electrode. A showerhead electrode would not be desirable for

incorporation in Murai's apparatus, at least because the doping gas is introduced through the gas supply tube 4 at the sidewall of the chamber 5. Accordingly, one skilled in the art would not have been motivated to form gas supply outlets in the upper electrode 2a, which is not in flow communication with the doping gas source and thus does not introduce the doping gas into the chamber. As such, one skilled in the art would not have been motivated to modify Murai's apparatus in the manner proposed in the final Official Action. See Ex Parte Hartmann, 186 USPQ at 367 and In re Ratti, 123 USPQ at 352.

However, at page 22, first full paragraph, of the final Official Action, the Examiner asserts that:

In response to applicant's argument that the Murai reference is not combinable with Degner, the test for obviousness is not whether the features of a secondary reference may be bodily incorporated into the structure of the primary references; nor is it that the claimed invention must be expressly suggested in any one or all of the references. Rather, the test is what the combined teachings would have suggested to those of ordinary skill in the art. (Emphasis added).

The Examiner's statement fails to take into account the entirety of M.P.E.P. § 2145(III), page 2100-167, which concludes by emphasizing that:

the claimed combination cannot change the principle of operation of the primary reference or render the reference inoperable for its intended purpose.

Because incorporating the features of Degner into Murai's apparatus would at the least change the principle of operation of Murai's apparatus, the proposed modification of Murai advanced in the final Official Action is improper. For at least these reasons, the applied references would not have rendered obvious the claimed subject matter.

However, the Examiner asserts at page 22, second full paragraph of the final Official Action, that “Degner et al. does not change the principle of operation of Murai since modifying Murai with Degner et al. would still allow for Murai to be used as an electrode consistent with the teachings of Murai” (emphasis added). Appellants disagree. Claim 1 recites a “showerhead electrode,” including a plurality of gas outlets arranged to distribute process gas. In stark contrast, Murai’s electrode is not a showerhead electrode and includes no gas outlets. The Examiner has established no motivation for one skilled in the art to substantially redesign Murai’s non-showerhead electrode to produce a showerhead electrode, as well as to modify other portions of Murai’s chamber to make it compatible with such modified electrode. Murai’s apparatus includes a gas supply system for introducing gas through the sidewall of the chamber, not through an electrode. As such, the asserted modification of Murai in view of Degner is based on hindsight derived from the present disclosure and thus is improper. See In re Lee, 61 USPQ2d at 1434.

Also, the unexpected results presented in the second Hubacek Declaration that are associated with the electrode recited in Claim 1 rebut the alleged *prima facie* obviousness. For reasons explained above, the unexpected results associated with the claimed electrode should properly be compared to Murai, which does not disclose a showerhead electrode having gas outlets. Accordingly, Claims 1, 4 and 5 are patentable over the applied references. Therefore, the rejection of these claims should be reversed.

2. Claims 6 and 7

For reasons discussed above, the combination of Murai and Degner does not recognize the unexpected advantages that are associated with the claimed low

resistivity silicon electrode having the thickness recited in Claim 1, much less also having the low resistivity recited in Claims 6 and 7. For example, the test results discussed in the second Hubacek Declaration regarding Appendices C and D demonstrated that the claimed low resistivity silicon electrode provides a desirable high etch rate, as well as improves plasma confinement and enhances the process window. Accordingly, the subject matter recited in Claims 6 and 7 is also patentable over the applied references. Therefore, the rejection of these claims should be reversed.

3. Claims 8-10

Each of Claims 8-10 depends from Claim 1 and recites a plasma reaction chamber including the showerhead electrode of Claim 1. Murai and Degner fail to suggest substantially modifying Murai's plasma chamber to produce the plasma reaction chamber including a showerhead electrode recited in any one of Claims 8-10, in light of the substantially different structure and principle of operation of Murai's apparatus. Accordingly, the plasma reaction chamber recited in Claims 8-10 is also patentable over the applied references. Therefore, the rejection of Claims 8-10 should be reversed.

4. Claims 30 and 38

Independent Claim 30 recites a low resistivity silicon electrode adapted to be mounted in a plasma reaction chamber including a confinement ring which is used in semiconductor substrate processing. The electrode comprises "a silicon electrode comprising a showerhead electrode having a plurality of gas outlets arranged to distribute process gas in the plasma reaction chamber during use of the showerhead electrode, the electrode having a thickness of about 0.375 inch to 0.5 inch and an

electrical resistivity of less than about 0.1 ohm-cm ...; and a graphite backing ring elastomer bonded to the electrode" (emphasis added). For reasons discussed above, Murai and Degner fail to suggest substantially modifying Murai's plasma chamber to produce a plasma reaction chamber including a showerhead electrode, much less a showerhead electrode including the combination of features recited in Claim 30. Thus, the subject matter recited in Claims 30 and 38 is also patentable over the combination of Murai and Degner. Therefore, the rejection of these claims should be reversed.

5. Claim 39

Claim 39 depends from Claim 1. The Examiner has failed to identify any disclosure in either of Murai or Degner of a plasma etch reactor comprising an electrode assembly that includes a confinement ring, as recited in Claim 39. Accordingly, the applied references do not support the alleged *prima facie* obviousness. Therefore, the rejection of Claim 39 should be reversed.

6. Claim 41

Claim 41 depends from Claim 30. The Examiner has failed to identify any disclosure in either of Murai or Degner of a plasma etch reactor comprising an electrode assembly that includes a confinement ring, as recited in Claim 41. Accordingly, the references do not support the alleged *prima facie* obviousness. Therefore, the rejection of Claim 41 should be reversed.

**F. Rejection of Claims 3, 21, 25, 27, 31, 33-37 and 40
Under 35 U.S.C. § 103(a) over Murai in view of Degner and Saito.**

1. Claims 3 and 27

Claims 3 and 27 depend from Claim 1. The combination of Murai and Degner does not suggest modifying Murai's apparatus to include a showerhead electrode, much less a showerhead electrode comprising the combination of features recited in Claims 3 and 27.

Saito also fails to suggest modifying Murai's apparatus to include a showerhead electrode comprising the combination of features recited in Claims 3 and 27.

Moreover, the unexpected results set forth in the second Hubacek Declaration that are associated with the claimed low resistivity silicon electrode are sufficient to rebut the alleged *prima facie* obviousness. The unexpected results of the claimed subject matter should be properly compared to Murai. Therefore, the rejection of Claims 3 and 27 should be reversed.

2. Claims 21, 25 and 31

Independent Claim 21 recites a low resistivity silicon electrode comprising "a silicon electrode comprising a showerhead electrode having a plurality of gas outlets arranged to distribute process gas in the plasma reaction chamber during use of the showerhead electrode, the gas outlets having a diameter of about 0.025 inch to 0.030 inch, the electrode having a thickness of about 0.25 inch to 0.5 inch and an electrical resistivity of less than about 0.1 ohm-cm ...; and a backing ring elastomer bonded to the electrode" (emphasis added). For reasons discussed above, Degner and Saito fail to provide the required suggestion or motivation to modify Murai's

apparatus to include a showerhead electrode, much less a showerhead electrode including the combination of features recited in Claim 21. For example, neither Murai, Degner nor Saito discloses a showerhead electrode including gas outlets having a diameter of about 0.025 inch to 0.030 inch, as recited in Claim 21. Accordingly, even if these references were combined, their combined teachings would not include every feature recited in Claim 21. Thus, the combination of references does not support the alleged *prima facie* obviousness.

Moreover, the above-discussed unexpected results associated with the claimed low resistivity silicon electrode are sufficient to rebut the alleged *prima facie* obviousness. Therefore, the rejection of Claims 21, 25 and 31 should be reversed.

3. Claim 33

Claim 33 depends from Claim 30. For reasons discussed above, Degner and Saito fail to provide the required suggestion or motivation to modify Murai's apparatus to include a showerhead electrode, much less a showerhead electrode including the combination of features recited in Claim 33. Therefore, the rejection of Claim 33 should be reversed.

4. Claims 34 and 35

Claims 34 and 35 depend from Claims 3 and 21, respectively, and recite the features of "the gas outlets have a diameter of about 0.025 inch to about 0.028 inch." For reasons discussed above, the combination of Murai, Degner and Saito does not disclose or suggest the combination of features recited in Claims 34 and 35, including the recited gas outlet diameter. Thus, the references do not support the alleged *prima facie* obviousness. Therefore, the rejection of Claims 34 and 35 should be reversed.

5. Claim 36

Claim 36 depends from Claim 33, which depends from Claim 30, and recites the features of “the gas outlets have a diameter of about 0.025 inch to about 0.028 inch.” For reasons discussed above, the combination of Murai, Degner and Saito does not disclose or suggest the combination of features recited in Claim 36, including the claimed gas outlet diameter. Thus, the references do not support the alleged *prima facie* obviousness. Therefore, the rejection of Claim 36 should be reversed.

6. Claim 40

The Examiner has failed to identify any disclosure in Murai, Degner or Saito of a plasma etch reactor comprising an electrode assembly that includes a confinement ring, as recited in Claim 40. Accordingly, the applied references do not support the alleged *prima facie* obviousness. Therefore, the rejection of Claim 40 should be reversed.

**G. Rejection of Claims 1, 3-10, 21, 25, 27, 30, 31 and 33-41
Under 35 U.S.C. § 103(a) Over Saito in View of Degner**

1. Claims 1, 3-10 and 27

Saito discloses a silicon sheet having a thickness that is significantly thinner than the electrode thickness of about 0.25 inch to 0.5 inch recited in Claim 1. Saito does not suggest an electrode having a thickness of about 0.25 to 0.5 inches. However, the Examiner contends that it would have been obvious to modify Saito's electrode in view of Degner to have a thickness of about 0.25 to 0.5 inches.

Degner does not suggest modifying Saito's electrode to result in the silicon electrode recited in Claim 1, which has a thickness of about 0.25 inch to 0.5 inch and

a low resistivity value. The Examiner has arbitrarily selected a particular portion of Degner's range, which is much higher than Saito's disclosed thickness, while disregarding other portions of Degner's range that are below or above the thickness range recited in Claim 1, including the thickness value actually disclosed by Saito. Moreover, Degner teaches minimizing the electrode thickness.

Moreover, the unexpected results presented in the second Hubacek Declaration associated with the electrode recited in Claim 1 having the claimed combination of thickness and low electrical resistivity rebut any alleged *prima facie* obviousness. It is improper to compare the results of the claimed subject matter to subject matter allegedly disclosed in the combination of Saito and Degner. Rather, the results of the claimed subject matter should be properly compared to Saito's thin electrodes. The second Hubacek Declaration provides evidence that such thin electrodes fail to provide the highly desirable properties that are provided by the electrode recited in Claim 1.

Thus, Claim 1 is patentable over Saito and Degner. Therefore, the rejection of Claims 1, 3-10 and 27 should be reversed.

2. Claims 21, 25, 31 and 37

For reasons discussed above, the combination of Saito and Degner does not suggest the low resistivity silicon electrode recited in Claim 21, which comprises "a silicon electrode comprising a showerhead electrode having a plurality of gas outlets arranged to distribute process gas in the plasma reaction chamber during use of the showerhead electrode, the gas outlets having a diameter of about 0.025 inch to 0.030 inch, the electrode having a thickness of about 0.25 inch to 0.5 inch and an

electrical resistivity of less than about 0.1 ohm-cm ...; and a backing ring elastomer bonded to the electrode" (emphasis added). For example, neither Saito nor Degner discloses a showerhead electrode including gas outlets having a diameter of about 0.025 inch to 0.030 inch, as recited in Claim 21. Accordingly, even if these references were combined, their combined teachings would not include every feature recited in Claim 21. Thus, the combination of references does not support the alleged *prima facie* obviousness.

Moreover, the above-discussed unexpected results associated with the claimed low resistivity silicon electrode are sufficient to rebut the alleged *prima facie* obviousness. Therefore, the rejection of Claims 21, 25, 31 and 37 should be reversed.

3. Claims 30, 33 and 38

Claims 33 and 38 depend from Claim 30. The low resistivity silicon electrode recited in Claim 30 is adapted to be mounted in a plasma reaction chamber including a confinement ring which is used in semiconductor substrate processing, and comprises "a silicon electrode comprising a showerhead electrode having a plurality of gas outlets arranged to distribute process gas in the plasma reaction chamber during use of the showerhead electrode, the electrode having a thickness of about 0.375 inch to 0.5 inch and an electrical resistivity of less than about 0.1 ohm-cm ...; and a graphite backing ring elastomer bonded to the electrode" (emphasis added). Saito's silicon sheet has a thickness of less than 0.2 inches, which is much thinner than the electrode thickness of about 0.375 inch to 0.5 inch recited in Claim 30. However, the Examiner contends that it would have been obvious to modify Saito's electrode in view of Degner to have a thickness of about 0.375 to 0.5 inches.

Degner does not suggest modifying Saito's electrode to result in the silicon electrode recited in Claim 30, which has a thickness of about 0.375 inch to 0.5 inch and a low resistivity value. The Examiner has arbitrarily selected a particular portion of Degner's range, that is, at a minimum, about twice as high as Saito's disclosed thickness, while disregarding other portions of Degner's range that are below or above the thickness range recited in Claim 30, including the thickness value actually disclosed by Saito. Moreover, Degner teaches minimizing the electrode thickness.

Furthermore, the unexpected results presented in the second Hubacek Declaration associated with the electrode recited in Claim 30 having the claimed combination of high thickness and low electrical resistivity rebut any alleged *prima facie* obviousness. These results should be properly compared to Saito's thin electrodes. The second Hubacek Declaration provides evidence that such thin electrodes fail to provide the highly desirable properties that are provided by the electrode recited in Claim 30.

Thus, Claims 30, 33 and 38 are patentable over Saito and Degner. Therefore, the rejection of these claims should be reversed.

4. Claim 34

Claim 34 depends from Claim 3, which depends from Claim 1, and recites the features of "the gas outlets have a diameter of about 0.025 inch to about 0.028 inch." The combination of Saito and Degner does not disclose or suggest the combination of features recited in Claim 34, including the claimed gas outlet diameter. Thus, the references do not support the alleged *prima facie* obviousness. Therefore, the rejection of Claim 34 should be reversed.

5. Claim 35

Claim 35 depends from Claim 21 and recites the features of “the gas outlets have a diameter of about 0.025 inch to about 0.028 inch.” The combination of Saito and Degner does not disclose or suggest the combination of features recited in Claim 35, including the claimed gas outlet diameter. Thus, the references do not support the alleged *prima facie* obviousness. Therefore, the rejection of Claim 35 should be reversed.

6. Claim 36

Claim 36 depends from Claim 33, which depends from Claim 30, and recites the features of “the gas outlets have a diameter of about 0.025 inch to about 0.028 inch.” The combination of Saito and Degner does not disclose or suggest the combination of features recited in Claim 36, including the claimed gas outlet diameter. Thus, the references do not support the alleged *prima facie* obviousness. Therefore, the rejection of Claim 36 should be reversed.

7. Claims 39 and 40

Claims 39 and 40 depend from Claims 1 and 21, respectively. The Examiner has failed to identify any disclosure in either of Saito or Degner of a plasma etch reactor comprising an electrode assembly that includes a confinement ring, as recited in Claims 39 and 40. Accordingly, the applied references do not support the alleged *prima facie* obviousness with respect to Claims 39 and 40. Therefore, the rejection of Claims 39 and 40 should be reversed.

8. Claim 41

The Examiner has failed to identify any disclosure in either of Saito or Degner of a plasma etch reactor comprising an electrode assembly that includes a

confinement ring, as recited in Claim 41. Accordingly, the applied references do not support the alleged *prima facie* obviousness with respect to Claim 41. Therefore, the rejection of Claim 41 should be reversed.

H. Rejection of Claims 1, 3-10, 21, 25, 27, 30, 31 and 33-41 Under 35 U.S.C. § 103(a) Over Degner in View of Saito

1. Claims 1, 3-10 and 27

As discussed above, Degner fails to disclose a single crystal silicon electrode having an electrical resistivity of less than 0.05 ohm-cm. However, the Examiner contends that Saito discloses this feature and that it would have been obvious to modify Degner's electrode to have the recited electrical resistivity.

The combination of Degner and Saito does not suggest modifying Degner's electrode plate to produce a silicon electrode having both the low electrical resistivity and thickness recited in Claim 1. In light of Saito's disclosure of an electrode thickness of less than 0.2 inch, and Degners' disclosure of minimizing the electrode thickness, the applied references provide no motivation to select the electrode thickness range recited in Claim 1 in combination with the claimed low resistivity for Degner's electrode.

Also, the unexpected results presented in the second Hubacek Declaration that are associated with the electrode of Claim 1 having the recited combination of thickness and low electrical resistivity rebut the alleged *prima facie* case of obviousness. For reasons discussed above, the unexpected results associated with the claimed electrode should be properly compared to Degner.

Thus, Claims 1, 3-10 and 27 are patentable over the combination of Degner and Saito. Therefore, the rejection of these claims should be reversed.

2. Claims 21, 25, 31 and 37

Regarding Claim 21, the combination of Degner and Saito does not suggest the recited low resistivity silicon electrode comprising “a silicon electrode comprising a showerhead electrode having a plurality of gas outlets arranged to distribute process gas in the plasma reaction chamber during use of the showerhead electrode, the gas outlets having a diameter of about 0.025 inch to 0.030 inch, the electrode having a thickness of about 0.25 inch to 0.5 inch and an electrical resistivity of less than about 0.1 ohm-cm ...; and a backing ring elastomer bonded to the electrode” (emphasis added). For example, neither Degner nor Saito discloses a showerhead electrode including gas outlets having a diameter of about 0.025 inch to 0.030 inch, as recited in Claim 21. Accordingly, even if these references were combined, their combined teachings would not include every feature recited in Claim 21. Thus, the combination of references does not support the alleged *prima facie* obviousness.

Moreover, the above-discussed unexpected results that can be achieved by the claimed low resistivity silicon electrode are sufficient to rebut the alleged *prima facie* obviousness. Therefore, the rejection of Claims 21, 25, 31 and 37 should be reversed.

3. Claims 30, 33 and 38

Claims 33 and 38 depend from Claim 30. Claim 30 recites a low resistivity silicon electrode adapted to be mounted in a plasma reaction chamber including a confinement ring which is used in semiconductor substrate processing. The electrode comprises “a silicon electrode comprising a showerhead electrode having a plurality of gas outlets arranged to distribute process gas in the plasma reaction

chamber during use of the showerhead electrode, the electrode having a thickness of about 0.375 inch to 0.5 inch and an electrical resistivity of less than about 0.1 ohm-cm ...; and a graphite backing ring elastomer bonded to the electrode" (emphasis added). Saito's silicon sheet is much thinner than the electrode recited in Claim 30. However, the Examiner contends that it would have been obvious to modify Degner's electrode in view of Saito to have a thickness of about 0.375 to 0.5 inches.

Appellants submit that Saito does not suggest modifying Degner's electrode to result in the silicon electrode recited in Claim 30, which has a thickness of about 0.375 inch to 0.5 inch and a low resistivity value. In stark contrast, Saito discloses an electrode thickness of less than 0.2 inch.

Moreover, the unexpected results presented in the second Hubacek Declaration associated with the electrode recited in Claim 30 having the claimed combination of thickness and low electrical resistivity rebut any alleged *prima facie* obviousness. Thus, Claims 30, 33 and 38 are patentable over Degner and Saito. Therefore, the rejection of these claims should be reversed.

4. Claim 34

Claim 34 depends from Claim 3, which depends from Claim 1, and recites that "the gas outlets have a diameter of about 0.025 inch to about 0.028 inch." The combination of Degner and Saito does not disclose or suggest the combination of features recited in Claim 34, including the claimed gas outlet diameter. Thus, the references do not support the alleged *prima facie* obviousness. Therefore, the rejection of Claim 34 should be reversed.

5. Claim 35

Claim 35 depends from Claim 21 and recites that “the gas outlets have a diameter of about 0.025 inch to about 0.028 inch.” The combination of Degner and Saito does not disclose or suggest the combination of features recited in Claim 35, including the claimed gas outlet diameter. Thus, the references do not support the alleged *prima facie* obviousness. Therefore, the rejection of Claim 35 should be reversed.

6. Claim 36

Claim 36 depends from Claim 33, which depends from Claim 30, and recites that “the gas outlets have a diameter of about 0.025 inch to about 0.028 inch.” The combination of Degner and Saito does not disclose or suggest the combination of features recited in Claim 36, including the claimed gas outlet diameter. Thus, the references do not support the alleged *prima facie* obviousness. Therefore, the rejection of Claim 36 should be reversed.

7. Claim 39

Claim 39 depends from Claim 1. The Examiner has failed to identify any disclosure in Degner or Saito of a plasma etch reactor comprising an electrode assembly that includes a confinement ring, as recited in Claim 39. Accordingly, the applied references do not support the alleged *prima facie* obviousness. Therefore, the rejection of Claim 39 should be reversed.

8. Claim 40

Claim 40 depends from Claim 21. The final Official Action has failed to identify any disclosure in Degner or Saito of a plasma etch reactor comprising an electrode assembly that includes a confinement ring, as recited in Claim 40.

Accordingly, the applied references do not support the alleged *prima facie* obviousness. Therefore, the rejection of Claim 40 should be reversed.

9. Claim 41

Claim 41 depends from Claim 30. The final Official Action has failed to identify any disclosure in Degner or Saito of a plasma etch reactor comprising an electrode assembly that includes a confinement ring, as recited in Claim 41.

Accordingly, the applied references do not support the alleged *prima facie* obviousness. Therefore, the rejection of Claim 41 should be reversed.

VII. CLAIMS APPENDIX

See attached Claims Appendix for a copy of the claims involved in the appeal.

VIII. EVIDENCE APPENDIX

See attached Evidence Appendix for copies of evidence relied upon by Appellant.

IX. RELATED PROCEEDINGS APPENDIX

See attached Related Proceedings Appendix for copies of decisions identified in Section II, supra.

X. CONCLUSION

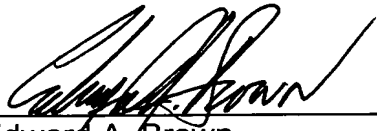
For the foregoing reasons, reversal of the rejection of Claims 1, 3-10, 21, 25, 27, 30, 31 and 33-41 is respectfully requested.

Respectfully submitted,

Burns, Doane, Swecker & Mathis, L.L.P.

Date December 27, 2005

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VIII. CLAIMS APPENDIX

The Appealed Claims

1. (Previously Presented) A low resistivity silicon electrode adapted to be mounted in a plasma reaction chamber including a confinement ring which is used in semiconductor substrate processing, comprising:

a silicon electrode comprising a showerhead electrode having a plurality of gas outlets arranged to distribute process gas in the plasma reaction chamber during use of the showerhead electrode, the electrode having a thickness of about 0.25 inch to 0.5 inch and an electrical resistivity of about 0.005 to 0.1 ohm-cm, the electrode having an RF driven or electrically grounded surface on one side thereof, the surface being exposed to plasma in the plasma reaction chamber during use of the electrode.

2. (Canceled)

3. (Previously Presented) The electrode of Claim 1, wherein the gas outlets have diameters of 0.020 to 0.030 inch and the gas outlets are distributed across the exposed surface.

4. (Original) The electrode of Claim 1, wherein the electrode comprises single crystal silicon or silicon carbide having heavy metal contamination of less than 10 parts per million.

5. (Original) The electrode of Claim 1, wherein the electrode comprises an electrically grounded upper electrode of a parallel plate plasma reactor.

6. (Previously Presented) The electrode of Claim 1, wherein the electrical resistivity of the electrode is less than 0.025 ohm-cm.

7. (Original) The electrode of Claim 1, wherein the electrical resistivity of the electrode is less than 0.05 ohm-cm.

8. (Previously Presented) A plasma etch reactor comprising an electrode assembly which includes the electrode of Claim 1, the electrode comprising:
a graphite backing ring elastomer bonded to the electrode; and
thin beads of an electrically conductive elastomeric material between the electrode and the graphite backing ring, the elastomeric material including an electrically conductive filler which provides an electrical current path between the electrode and the graphite backing ring.

9. (Original) A plasma etch reactor having an electrode assembly which includes the electrode of Claim 1, the electrode being resiliently clamped to a support member by a clamping member.

10. (Previously Presented) A plasma reaction chamber including the showerhead electrode of Claim 1, the showerhead electrode being bonded or clamped to a temperature-controlled member in an interior of the plasma reaction chamber, the temperature-controlled member including a gas passage supplying a process gas to the showerhead electrode, the temperature-controlled member including a cavity and at least one baffle plate located in the cavity, the gas passage supplying process gas so as to pass through the baffle plate prior to passing through the showerhead electrode.

11-20. (Canceled)

21. (Previously Presented) A low resistivity silicon electrode adapted to be mounted in a plasma reaction chamber including a confinement ring which is used in semiconductor substrate processing, comprising:

a silicon electrode comprising a showerhead electrode having a plurality of gas outlets arranged to distribute process gas in the plasma reaction chamber during use of the showerhead electrode, the gas outlets having a diameter of about 0.025 inch to 0.030 inch, the electrode having a thickness of about 0.25 inch to 0.5 inch and an electrical resistivity of less than about 0.1 ohm-cm, the electrode having an RF driven or electrically grounded surface on one side thereof, the surface being exposed to plasma in the plasma reaction chamber during use of the electrode; and
a backing ring elastomer bonded to the electrode.

22-24. (Canceled)

25. (Previously Presented) The electrode of Claim 21, wherein the backing ring is of silicon carbide or graphite.

26. (Canceled)

27. (Previously Presented) The electrode of Claim 1, wherein the gas outlets comprise ultrasonically drilled holes.

28-29. (Canceled)

30. (Previously Presented) A low resistivity silicon electrode adapted to be mounted in a plasma reaction chamber including a confinement ring which is used in semiconductor substrate processing, comprising:

a silicon electrode comprising a showerhead electrode having a plurality of gas outlets arranged to distribute process gas in the plasma reaction chamber during

use of the showerhead electrode, the electrode having a thickness of about 0.375 inch to 0.5 inch and an electrical resistivity of less than about 0.1 ohm-cm, the electrode having an RF driven or electrically grounded surface on one side thereof, the surface being exposed to plasma in the plasma reaction chamber during use of the electrode; and

a graphite backing ring elastomer bonded to the electrode.

31. (Previously Presented) The electrode of Claim 21, wherein the backing ring is elastomer bonded to the electrode by thin beads of an electrically conductive elastomeric material between the backing ring and electrode, the elastomeric material including an electrically conductive filler.

32. (Cancelled)

33. (Previously Presented) The electrode of Claim 30, wherein the gas outlets have diameters of 0.020 to 0.030 inch and the gas outlets are distributed across the exposed surface.

34. (Previously Presented) The electrode of Claim 3, wherein the gas outlets have a diameter of about 0.025 inch to about 0.028 inch.

35. (Previously Presented) The electrode of Claim 21, wherein the gas outlets have a diameter of about 0.025 inch to about 0.028 inch.

36. (Previously Presented) The electrode of Claim 33, wherein the gas outlets have a diameter of about 0.025 inch to about 0.028 inch.

37. (Previously Presented) The electrode of Claim 21, wherein the electrode has an electrical resistivity of 0.005 to 0.02 ohm-cm.

38. (Previously Presented) The electrode of Claim 30, wherein the electrode has an electrical resistivity of 0.005 to 0.02 ohm-cm.

39. (Previously Presented) A plasma etch reactor comprising an electrode assembly including the electrode of Claim 1 and a confinement ring.

40. (Previously Presented) A plasma etch reactor comprising an electrode assembly including the electrode of Claim 21 and a confinement ring.

41. (Previously Presented) A plasma etch reactor comprising an electrode assembly including the electrode of Claim 30 and a confinement ring.



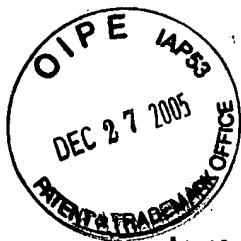
IX. EVIDENCE APPENDIX

The following evidence is relied upon by Appellant in this appeal:

- 1) Second Declaration by Jerome Hubacek Under 37 C.F.R. § 1.132 filed on March 29, 2005.

X. RELATED PROCEEDINGS APPENDIX

None.



Patent
Attorney's Docket No. 015290-457

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of

Jerome S. Hubacek et al.

Application No.: 09/749,916

Filed: December 29, 2000

For: ELECTRODE FOR PLASMA
PROCESSES AND METHOD FOR
MANUFACTURE AND USE
THEREOF

)
)
) Group Art Unit: 1763

)
) Examiner: LUZ L ALEJANDRO
) MULERO

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) Confirmation No.: 6834
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SECOND DECLARATION BY JEROME S. HUBACEK UNDER 37 C.F.R. § 1.132

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

I, Jerome S. Hubacek, hereby state as follows:

1. I am an inventor of subject matter claimed in the above-identified application.
2. Tests were performed under my supervision using low resistivity, single crystal silicon showerhead electrodes in a plasma reaction chamber. The showerhead electrodes had a plurality of gas passages (outlets) with diameters of 0.025 inch arranged to distribute a process gas in the reaction chamber during use of the electrodes. The showerhead electrodes had thicknesses of 0.15 inch, 0.18 inch, 0.25 inch, and 0.35 inch. The showerhead electrodes having thicknesses of 0.15 inch, 0.18 inch and 0.25 inch included 3249 gas passages, while the showerhead electrode having a thickness of 0.35 inch included 2437 gas passages. The showerhead electrodes had an electrical resistivity in the range of from about

0.005-0.02 ohm-cm. The showerhead electrodes were bonded to a graphite support member by an elastomeric joint.

Power levels of 1000 watts, 2000 watts, and 3000 watts were applied to each of the showerhead electrodes. In addition, a power level of 4000 watts was applied to the thicker showerhead electrodes having a thickness of 0.25 inch and 0.35 inch. The center-to-edge temperature gradients of the showerhead electrodes having a thickness of 0.15 inch, 0.18 inch, and 0.35 inch were modeled based on temperature measurements made for the showerhead electrode having a thickness of 0.25 inch. The test results are plotted in the graph in attached Appendix A. As shown in the graph, at each applied power level, the center-to-edge temperature gradient decreases as the showerhead electrode thickness increases. For example, at an applied power level of 2000 watts, decreasing the electrode thickness below 0.25 inch sharply increases the center-to-edge temperature gradient. At an applied power level of 3000 watts, increasing the electrode thickness from 0.25 inch to 0.30 inch reduces the center-to-edge temperature gradient by about 15% (on the centigrade scale). Increasing the electrode thickness from 0.25 inch to 0.35 inch at the same applied power level reduces the center-to-edge temperature gradient by about 35%.

3. The claimed showerhead electrode allows longer production times before replacement of the electrode is needed. Increasing the showerhead electrode thickness unexpectedly provides better thermal uniformity while increasing the lifetime of the electrode (i.e., the number of RF hours that the electrode can be used). Thicker electrodes allow an increase in the maximum amount of power that the showerhead electrode can be operated at without failure. At a set power level,

increasing the showerhead electrode thickness reduces the center-to-edge thermal gradient of the electrode (see Appendix A), which surprisingly reduces the probability of cracking of the electrode, especially at high power levels (e.g., 4000 watts).

4. The showerhead electrode thickness versus the power level applied to the electrode was measured, and the test results are plotted in the graph in attached Appendix B. The region above line A represents the experimentally determined operating range in which the probability of electrode cracking is low, while the region below line A represents the operating range in which the probability of electrode cracking is high. Extrapolation of line A to greater electrode thickness values shows that showerhead electrodes having a thickness of 0.25 inch or greater can be operated at significantly higher power levels than thinner electrodes.

5. Increasing the showerhead electrode thickness while using the same diameter gas passages in the electrode surprisingly reduces particle contamination of processed wafers. The increased length of the gas passages also increases the gas pressure behind the electrode. Showerhead electrodes having a thickness of 0.25 inch and larger reduce deposition of polymer particles behind the electrode, as compared to the electrodes having a thickness of 0.15 inch and 0.18 inch. The claimed electrode can provide beneficial reduction in particle defects.

6. The claimed showerhead electrode provides better RF coupling than thinner showerhead electrodes. As increasing the thickness of the showerhead electrode decreases the electrical resistance of the electrode from the center to the

edge, ohmic losses in the electrode can be reduced. Coupling of radio frequency (RF) power to plasma generated in the plasma reactor can be enhanced. As shown in the Table at page 14 of the above-identified application, reducing the impedance path of the RF results in a higher etch rate of substrates in the plasma reactor using the same gas chemistry and reactor conditions, including the same set power level applied to the electrode.

7. Reducing the electrode resistance also improves plasma confinement in the plasma reactor. Tests were performed under my supervision using four, low resistivity, single crystal silicon showerhead electrodes A-D and also a standard higher resistivity single crystal silicon showerhead electrode in a plasma reaction chamber. The low resistivity showerhead electrodes had a thickness of 0.25 inch and an electrical resistivity of from about 0.005-0.02 ohm-cm. Low resistivity showerhead electrode A included 829 gas passages with diameters of 0.025 inch, and low resistivity showerhead electrodes B-D each included 3249 gas passages with diameters of 0.025 inch. The standard resistivity showerhead electrode had a thickness of 0.25 inch, an electrical resistivity of 10 ohm-cm and included 3249 gas passages with diameters of 0.025 inch. The showerhead electrodes were each bonded to a graphite support member by an elastomeric joint.

The standard resistivity and low resistivity showerhead electrodes were installed in a plasma reactor including plasma confinement rings for confining the plasma in confinement region between the showerhead electrode and the lower electrode. A process gas (i.e., a gas mixture of $\text{Ar}/\text{CF}_4/\text{O}_2/\text{CHF}_3$) was energized to produce plasma in the plasma reactor by applying 1000 watts power at a frequency

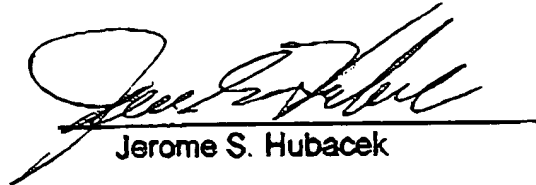
of 27 MHz and 2000 watts at a frequency of 2 MHz to the lower electrode while the upper electrode was grounded (i.e., provided a return path). Each of the electrodes was tested to determine the maximum flow rate of a constituent of the gas mixture (argon) that could be used without plasma unconfinement in the plasma reactor, i.e. the gas flow rate above which the plasma was no longer confined within the plasma confinement rings.

The flow rate of argon was increased while maintaining the same flow rates of the other gases of the gas mixture. The test results are shown in Appendix C. As shown, for the standard resistivity showerhead electrode, there was plasma unconfinement at an argon flow rate of less than 200 sccm. In contrast, for the low resistivity showerhead electrodes, higher argon flow rates ranging from 200 sccm (showerhead electrode D) up to 1000 sccm (showerhead electrode A) were used with stable plasma operation. The higher argon flow rates provide a larger confinement window for plasma processing operations using the low resistivity showerhead electrodes.

Appendix D shows the measured impedance values for the low resistivity showerhead electrodes A, B and D, where power at frequencies of 2 MHz and 27 MHz was applied separately to the lower electrode. As shown in Appendix D, for both operating frequencies, showerhead electrode A had the lowest impedance value, showerhead electrode D had the highest impedance value and showerhead electrode B had an impedance value between that of electrodes A and D. Accordingly, the impedance values shown in Appendix D correlate to the plasma confinement results shown in Appendix C for the low resistivity showerhead electrodes. That is, decreasing the impedance of the electrode improves

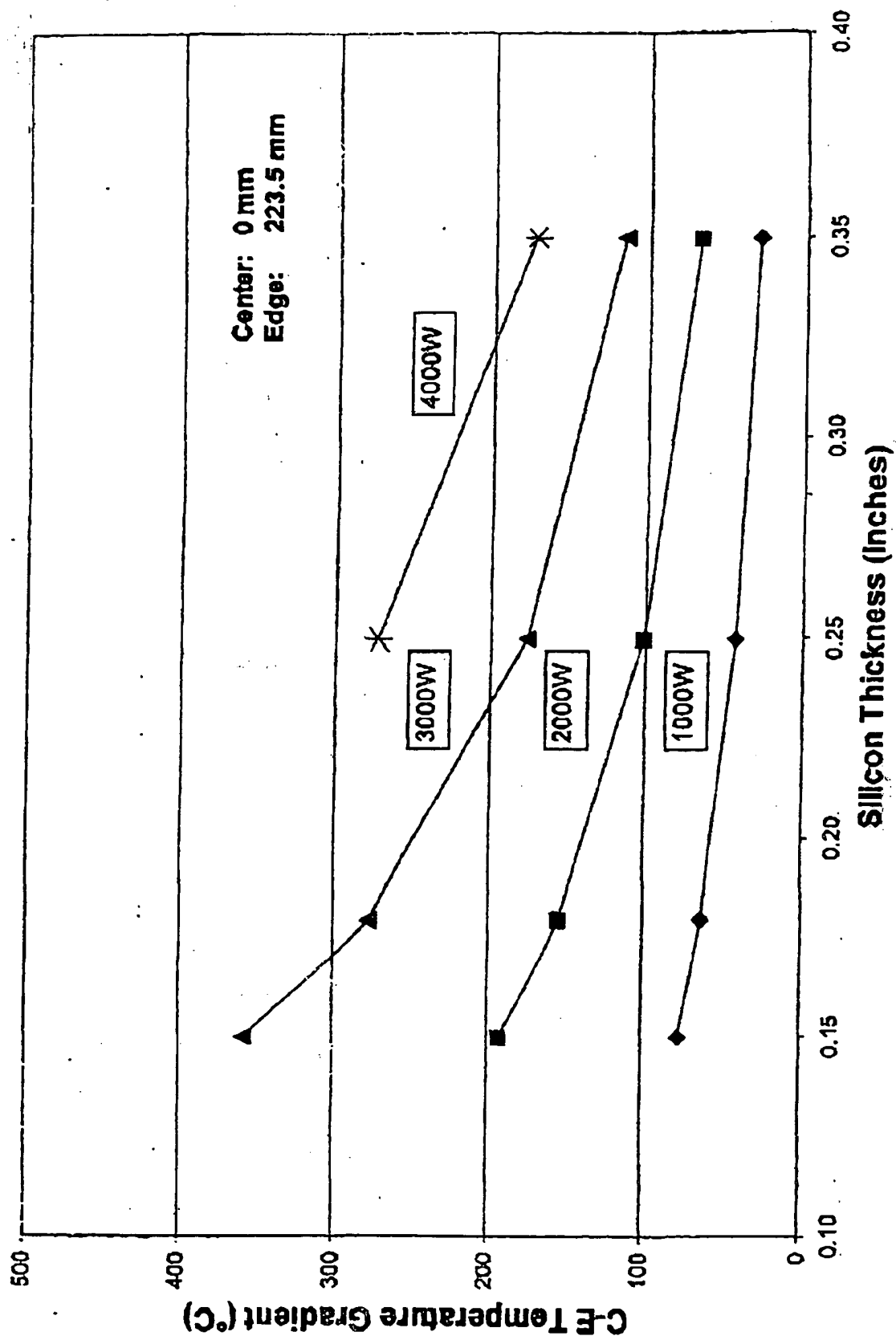
confinement. Such performance benefits are highly desirable in semiconductor processing because by improving confinement, the confinement window and the corresponding process window are increased.

8. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

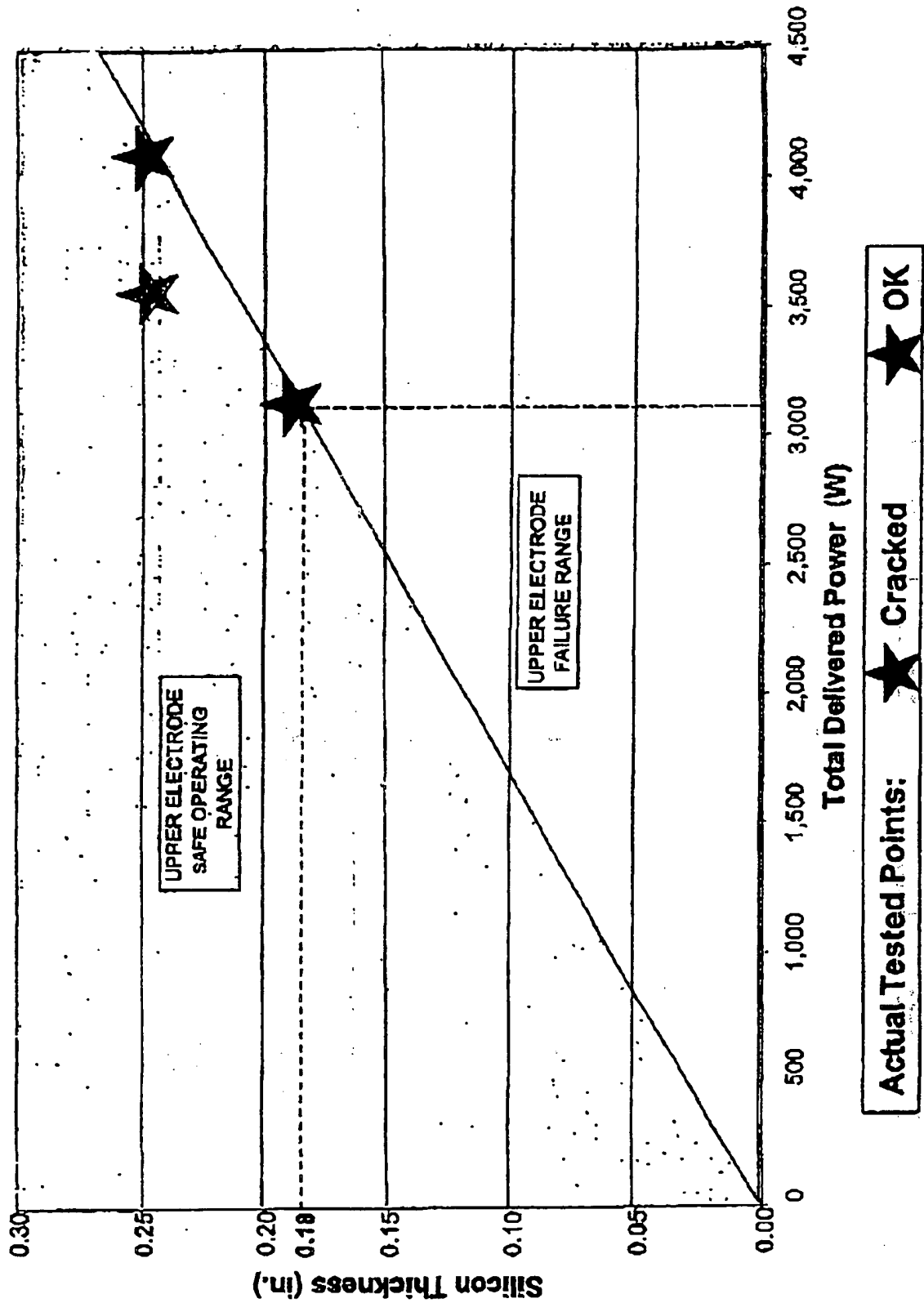
Date: 3/25/05
Jerome S. Hubacek



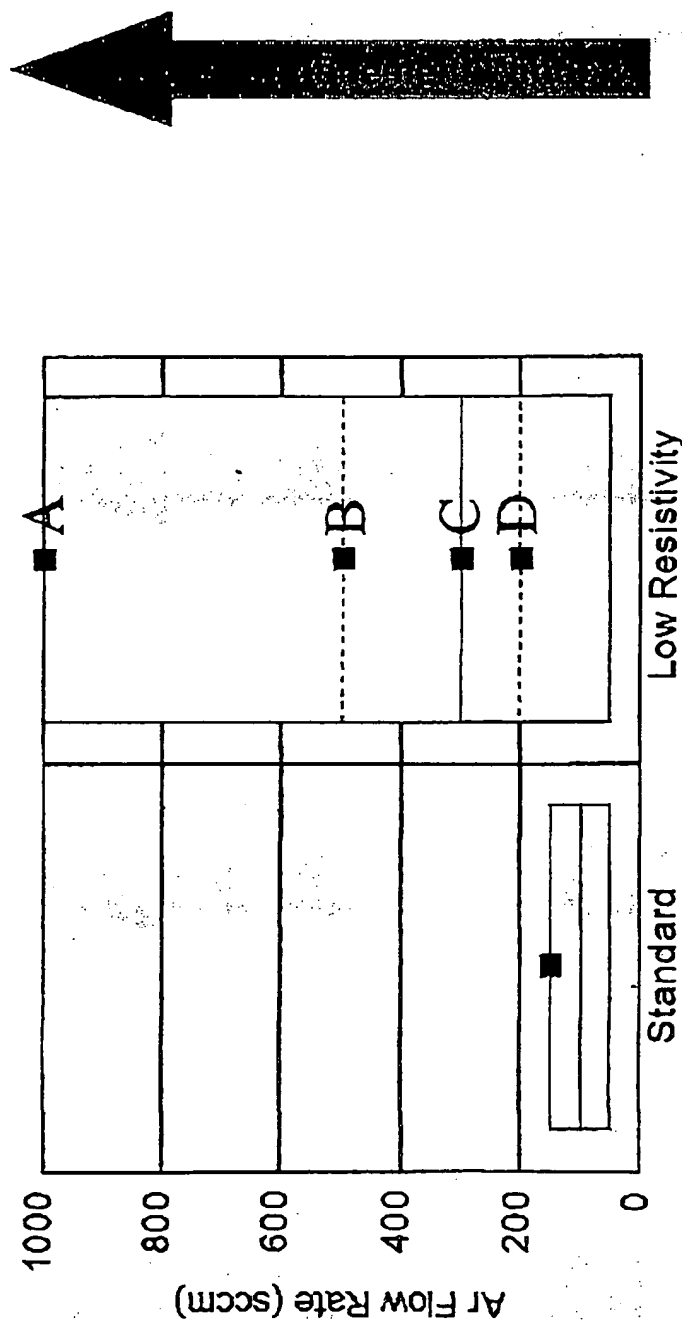
Appendix A



Appendix B



Range of Ar Flow Rates for Stable Plasma Operation



- A: P/N 716-461378-JH2 S/N 16625-6
 B: P/N 839-011907-121 S/N 1047-9
 C: P/N 839-011907-121 S/N 1047-15
 D: P/N 839-011907-121 S/N 1047-21
- 829 hole low resistivity electrode
 3249 hole low resistivity electrode
 3249 hole low resistivity electrode
 3249 hole low resistivity electrode

